

focus on . . .

Welding and Joining Technology

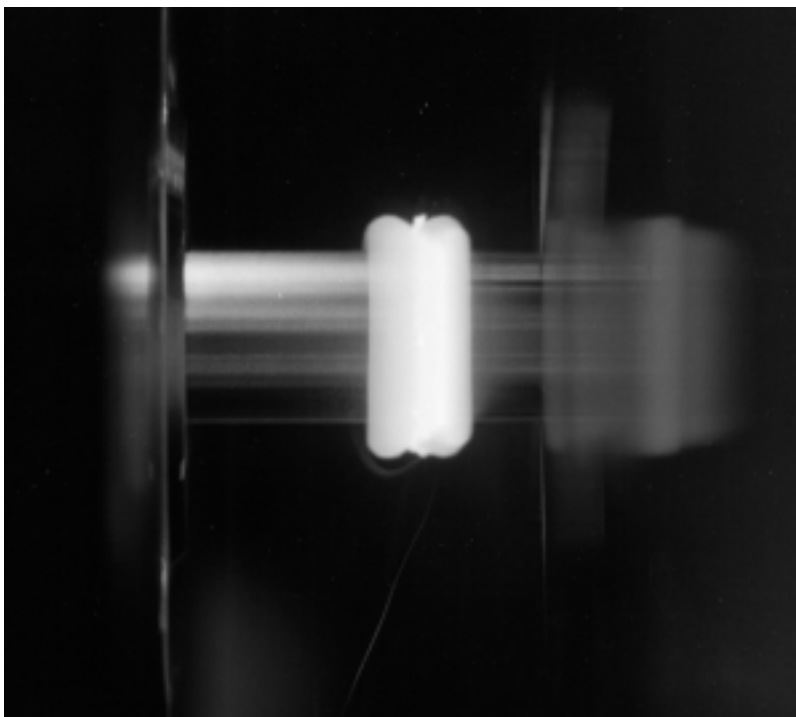
As one of the largest teams of the Materials Science and Technology: Metallurgy Group at Los Alamos, the Welding and Joining Section (WJS) has nine staff members and eight technicians. This multidisciplinary group of researchers is knowledgeable in the fundamentals of material weldability, solidification behavior, defect formation, diffusion bonding, brazing, arc physics, laser physics and optics, energy beam physics, and control theory and automation.

In addition to the diverse background of the staff, each member has gained expertise in one of the cornerstones of welding engineering, including welding metallurgy, weld processes, weld design and modeling, weld process control and automation, and non-destructive evaluation. We have applied research and development experience in welding metallurgy, ferrous and nonferrous metallurgy, welding processes and automation, finite element analysis, and failure analysis. We possess unique skills with respect to refractory metal joining and nuclear material joining and encasement. Several staff members have industrial experience as well as a long history of successful partnerships with industries and universities.

The WJS is the largest precision welding and materials joining team in the Department of Energy's weapons complex and serves a vital role in ensuring the safety and reliability of the U.S. arsenal. We work extensively with customers within the DOE, Department of Defense, and other government agencies, as well as with external defense contractors. We specialize in the weldability of difficult-to-weld materials or materials that pose a radiological or toxicological hazard. Our experience in serving the nuclear weapons, space power, and accelerator technology programs has provided us the experience to serve the needs of programs requiring high levels of quality and precision for a wide range of unique materials.

The WJS supports in-house engineering expertise by leveraging critical resources. We provide selection assistance and support for all welding and joining processes and help implement and develop optimum welding systems and procedures for the desired level of quality and cost. We work closely with staff engineers and scientists to define project goals and tailor the project to meet specific needs. In addition, we provide a wide range of equipment and experienced staff to develop welding applications and resolve problems using unique tools for productivity enhancement and quality assurance.

With our expertise in the areas of materials, welding processes, and engineering, we have the ability to address all aspects of component welding, repair and maintenance operations, and nondestructive evaluation techniques. We have the skills and capabilities to explain and predict the performance of structural materials, weld metals, and welded structures and, using this capability, to predict the performance of welded designs and various material combinations. We specialize in troubleshooting from process development to failure analysis of welded components. Our interactions with industry range from focused problem solving to award winning R&D.



We provide results-oriented welding and joining solutions through technical assistance, research and development, consultation, and training.

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U.S. Patents

5,837,960, "Laser production of articles from powders," G. K. Lewis, J. O. Milewski, R. B. Nemec, M. R. Barbe, and D. A. Cremers, November 17, 1998

5,760,365, "Narrow gap laser welding," J. O. Milewski and E. Sklar, June 2, 1998

R&D 100 Award

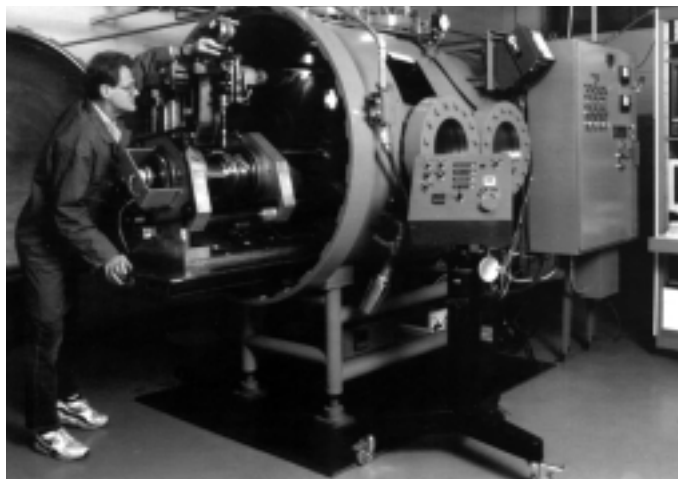
"Directed light fabrication of complex metal parts," 1994

Welding Metallurgy/Weldability Capabilities and Developments

- Characterization of weld and heat-affect zone cracking sensitivity
- Welding materials selection
- Consumables development and evaluation
- Knowledge of grain boundary character distribution and its influence on weldability
- Permit for welding of toxic and radioactive materials, including beryllium and transuranics
- Failure analysis
- Gleeble™ thermal-mechanical simulator with 10-ton force load frame

Automation and Control Technologies and Equipment

- Top-side penetration sensing using arc light and the weld pool's natural resonant frequency
- Penetration control throughout varying thermal regions
- Synchronous excitation of the weld pool
- Laser-based weld vision system
- Computerized, multichannel welding data acquisition equipment with full-range temperature measurement capability
- High-speed video
- Real-time process monitoring and control using high-performance parallel digital signal processors (DSPs)
- Commercial and LANL-developed software packages for in-process and post-process analysis of feedback data
- Intelligent techniques, such as neural networks, evolutionary computing, genetic algorithm, fuzzy logic, and expert systems to predict, monitor, and control various aspects of the joining process

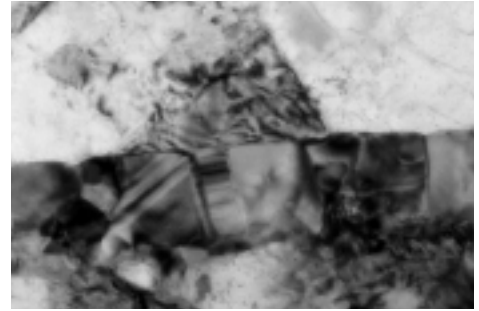


High-Energy Density Welding Technologies and Equipment

- 150 kV, 7.5 kW high-voltage electron beam welders
- 10 W Nd:YAG laser, pulsed with 3-axis motion
- 50 W Nd:YAG laser, pulsed with 2-axis motion
- 400 W Nd:YAG laser, pulsed
- 1500 W Nd:YAG laser, pulsed with 3-axis motion
- 1000 W Nd:YAG laser, pulsed with 5-axis motion, processing of special nuclear materials
- 2 kW CW Nd:YAG laser, pulsed with 5-axis motion
- 700 W CW CO₂ laser, 2-axis motion
- 190 kW peak power titanium:sapphire femtosecond laser, 80 fs pulse, capable of cutting or drilling
- 10 W Q-switched Nd:YAG, fundamental and harmonics
- Powder and wire feeders
- Electron beam profiling (Faraday cup) and diagnostics
- Laser beam focusing, profiling and diagnostics equipment (Precitec)

Brazing and Soldering Technologies and Equipment

- Vacuum furnaces with special high-range tungsten hot zone (1650 °C max.)
- Patented infrared brazing processes using non-imaging optics
- Resistance and electron beam brazing
- Brazing of metal-graphite and ceramic-metal joints
- Hermetic sealing
- Glass to metal joining/sealing
- Active filler alloy brazing
- Diffusion bonding



Process Modeling, Analysis, and Software Capabilities

- Neural network-based solutions
- OptiCAD: optical ray tracing software for the design and analysis of energy concentrating laser weld joints and brazing applications
- ProEngineer/ProManufacture for 3D solid CAD/CAM design and control up to 5-axes
- MATLAB for PC based data analysis
- LabView for data acquisition system, process monitoring and control of laser equipment, pulsed laser waveform analysis and monitoring of part geometry before and after welding to characterize distortions and shrinkage
- Telluride: a LANL-developed, model-based, computational fluid dynamics software package designed to accurately model material microstructure during both welding and casting operations
- Analytical modeling using inverse heat conduction solutions

Resistance and Solid-State Welding Capabilities and Developments

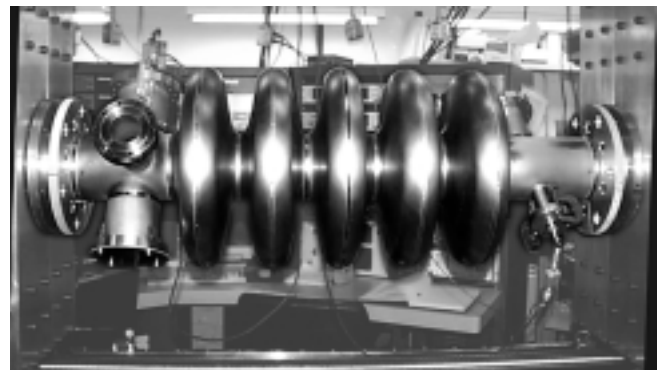
- Resistance upset welding system with 5-ton upset force (in controlled vacuum environment)
- Micro-resistance spot welding for small diameter wire
- Capacitor discharge welding
- Inertia friction welding system with 6.5-ton upset force
- Dissimilar metal joining, e.g., ferrous and nickel-base alloys to niobium and titanium alloys

Arc Welding Technologies and Equipment

- Standard and pulsed gas metal arc, and gas tungsten arc with cold and hot wire feed in a controlled inert atmosphere chamber
- High purity glove boxes with controlled atmospheres
- Plasma arc cutting
- Active argon scrubbing
- Hyperbaric chamber capability

Other Capabilities

- Design of experiments
- 100% in-process quality assurance
- Manufacturing process knowledge management
- Process and equipment selection optimization and implementation
- State-of-the-art nondestructive evaluation techniques and equipment



Selected Publications

Cola, M. J., Teter, D. F., Papin, P. and Taylor, T., 1998, "Optical and electron microscopy of ductility-dip cracking in filler metal 52—Initial Studies," Proceedings of the International Trends in Welding Research, Ed. by Vitek, J, et al., Callaway Gardens Resort, Pine Mountain, GA, pp.781-786.

Davé, V. R. and King, W. H., 2000, "Process control roadmaps as conceptual tools in the design of 100% quality-assured brazing processes," Proceedings of the International Brazing and Soldering Conference, Albuquerque, NM, April 2-5, pp. 100-107.

Hartman, D. A., DeLapp, D. R., Cook, G. E., and Barnett, R. J., 1999, "Intelligent control in arc welding," Smart Engineering Design, Ed. by Cihan H. Dagli, et al. ASME Press, New York, NY, November 7-10, pp. 715-725.

Hill, R. and Lewis, G. K., 1998, "Directed light fabrication of aircraft components," Aerospace Engineering, November, v.18 (#11), pp. 31-33.

Milewski, J. O. and Barbe, M. B., 1999, "Modeling and analysis of laser melting within a narrow groove weld joint," Welding Journal, v.78, No. 4, pp. 109s.

Pierce, S. W., Burgardt, P., and Olson, D. L., 1999, "Thermocapillary and arc phenomena in stainless steel welding," Welding Journal, v.78, No. 2, pp. 45s.

Recent Awards

Cola, M. J., Teter, D. F., Lyons, M. and Kelly, A. M., 1999, First Place Award—Professional Poster Division, "Microstructural Aspects of Inertia Friction Welds Between Titanium and Stainless Steel Using a Niobium Interlayer," 80th Annual American Welding Society Convention, St. Louis, MO, April 12-15.

Hartman, D. A., Cola, M. J., Davé, V. R., 2000, First Place Award—Professional Poster Division, "Automated Inspection: Providing 100% In-Process Quality-Assurance for Inertia Friction Welding," 81st Annual American Welding Society Convention, Chicago, IL, April 24-28.

Nugent, A. and Piltch, M. S., 1999, First Place Award—Student Poster Division, "Rocket Nozzle Fabrication by Laser Welding," 80th Annual American Welding Society Convention, St. Louis, MO, April 12-15.